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UNITED STATES ARMY.

EARLY DAYS OF THE ENGINEER SCHOOL OF APPLICATION

By
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ENGINEER SCHOOL OF APPLICATION,
WASHINGTON BARRACKS, WASHINGTON, D. C.,
—1904.—

CONTENTS.

Page.

Engineer troops in the U. S. Army ---- 1
Disposition of the Battalion after the Civil War ---- 2
Inauguration of the Engineer School of Application ---- 4
The Essayons Club ---- 8
Meteorology in connection with Hypsometry ---- 10
Military reconnaissances and surveys ---- 10
Field Astronomy ---- 11
Tidal and current measurements ---- 14
Military Photography ---- 15
The Engineer Depot ---- 15
The submarine mining service ---- 17
Special researches at Willets Point ---- 23
Military peace record of the Battalion ---- 26
End of tentative development ---- 30

Illustrations.

General Henry L. Abbot .... *Frontispiece.*

Facing page.

Commanding officers' quarters 2
Officers' mess 4
Officers' quarters 6
Mine explosion 7
Barracks 8
Field astronomical observatory 11
Photographic laboratory 12
Mule decapitated with dynamite 14
Submarine mine explosion 16
Granite casemated battery 17
Double submarine explosion 18
Destruction of the *Olive Branch* 20
Submarine mine explosion 24
Explosion under ice 28
Torpedo laboratory 34
Bachelor officers' quarters and barracks 38
Chapel 40

EARLY DAYS OF THE ENGINEER SCHOOL OF APPLICATION,

By

BREVET BRIGADIER GENERAL HENRY L. ABBOT,
Colonel, U. S. Army, Retired.

The intimate connection which has always existed between the Engineer School of Application and the Engineer troops, renders a brief outline of the successive organizations of the latter important to an understanding of the former. Indeed to Company A under Lieut. Duane much credit is due for valuable technical researches, before the Civil War had demonstrated the necessity of a special School for this among other purposes.

ENGINEER TROOPS IN THE U. S. ARMY.

Subsequent to the Act of March 16, 1802, fixing the military peace establishment of the United States, there were no engineer troops in service, other than the Company of Bombardiers attached for a short time to the Military Academy, until Company A was raised by Act of May 15, 1846, to meet the exigencies of the War with Mexico. After its close the Company was stationed at West Point, except when it accompanied the expedition to Utah, although several detachments served in the West on duty with other troops in the fifties. At West Point the Company assisted in the instruction of the cadets in practical military engineering, but its most important duty was experimenting with different patterns of bridge trains to take the place of the rubber pontons which had proved to be ill adapted to the needs of the service. These investigations were conducted chiefly by Lieut. Duane, and when the Civil War occurred the results proved to be of immense value.

At the outbreak of that war Congress authorized, by Act of August 3, 1861, three more companies of engineeer troops, and by Act of

August 6, 1861, one company of topographical engineer troops, the engineer service at that date being divided between these two Corps. After their consolidation, by Act of March 3, 1863, four of these companies served as a Battalion attached directly to the Headquarters of the Army of the Potomac, performing gallant and distinguished service from Yorktown to Appomattox. Company E was recruited at Detroit in 1865. The Battalion organization was first formally recognized by Congress by Act of July 28, 1866.

The original organization of Company A called for 100 enlisted men. This number, and that of each of the new companies, was established at 150 men by the Acts authorizing the latter. In consequence of the reduction of the army after the war, the number allowed to be recruited for the Battalion was fixed in December, 1870, at 354 men; on July 1, 1871, at 301 men; on June 3, 1873, at 350 men; and on May 9, 1877, at 200 men. On August 5, 1884, the number was increased to 450 men. The first reduction occasioned the breaking up of the Posts at Yerba Buena Island and Jefferson Barracks, the reduction of Company D to a skeleton organization, and the transfer of Company E to West Point.

DISPOSITION OF THE BATTALION AFTER THE CIVIL WAR.

When the Army of the Potomac was mustered out of service at the close of the war it became a question what disposition should be made ot the Battalion. West Point it was foreseen would soon cease to be exclusively an Engineer Post, and moreover there were no buildings there available for so many men, and for the storage of the immense accumulations of engineeer materials in Virginia that were worthy of preservation. At Willets Point the temporary buildings of the Grant General Hospital would afford immediate accommodation, and it was decided to create there an independent engineer post under the direct control of the Chief of Engineers; to send Company A back to West Point; to send Companies B, C and D to Willets Point; and to send Company E to Jefferson Barracks, where were to be stored the accumulations of Engineer property remaining after the discharge of the Western Armies. Subsequently, under General Humphreys' administration, Company D was transferred to California in August, 1867, for such military duty as might be required by the Commanding General, taking station first at Fort Point and later at Yerba Buena Island; and Company A was transferred from West Point to Willets Point, observatory was necessary, and funds were so hard to obtain in those days that it was only early in 1869 that regular observations could begin. All officers on duty with the Battalion were put on the roster, and weather permitting the hours from sunset to midnight were devoted to the work. Each officer was supplied with the printed blank forms used by the Corps for recording the notes and making the computations; and as these after approval became his personal property they could hardly fail to be convenient at a later day if suddenly detailed on astronomical duty. As the latitude and longitude of the observatory would soon be accurately known, the former by many zenith telescope observations and the latter by time signals from Washington, the individual results of each officer were tabulated and announced annually in Battalion Orders, which thus became useful for reference in estimating the probable absolute errors to which simular observations and methods in the field are liable. This annual publication, which continued during my entire tour of duty, ultimately resulted in connecting our little observatory with the discovery of a new oscillating motion of the axis of the earth, as will appear below.

During the first twelve years fifty officers of the Corps had the benefit of practice, in this old observatory. The building was small and the instruments were of ancient patterns, but they were replaced in the spring of 1879 by a new outfit entirely satisfactory in these respects. The building was constructed almost wholly by Engineer soldiers. A lithograph showing its dimensions and arrangements was appended to Battalion Order No. 3, of 1881 (reprinted in Annual Report of Chief of Engineers for 1881), which also contained a full description of the instruments, about a dozen in number and including the latest types. Prof. T. H. Safford after visiting it remarked to me that in his opinion it was the best observatory in the United States for teaching practical astronomy. The regular course included determination of latitude by different types of zenith telescope and by the sextant; the determination of longitude by moon culminations, by occulations by the dark limb of the moon, by eclipses of Jupiter's satellites, and (for practice in using the sextant in oblique planes) by lunar distances. Any unusual astronomical event was of course observed and reported, as for example the transit of Mercury on May 6, 1878, in connection with which the longitude of the observatory was determined by time signals sent for ten days from the Naval observatory at Washington; and the transit of Venus on December 6, 1882, of which the results were reported in full in Paper V of the Engineer

arriving on September 3, 1867, being replaced by a small detachment from the Battalion; the instruction of the companies at the three Engineer Posts was to be prescribed by the Battalion Commander, even the Post returns being forwarded through him; he also acted as Superintendent of the Engineer Recruiting Service, officers of the Corps on other duty at several cities having charge of the enlistments. Such were the general conditions under which the Engineer School of Application originated. It really was divided between three Posts, prior to the abandonment of Yerba Buena Island and Jefferson Barracks in 1871.

When the Army of the Potomac was mustered out of service in the summer of 1865, General Duane who had been its Chief Engineer reported for duty to General Delafield, then Chief of Engineers. The latter asked what service would be agreeable to him, remarking that he was one of the first officers of the Corps to return to duty after distinguished service throughout the entire war in his legitimate arm of service. General Duane replied that he should like to command the Battalion of Engineers. General Delafield acceded, and he was ordered to take charge of the construction of the fortifications at Willets Point, and to command the new Engineer Post. Companies B and D were sent there to receive and store the engineer property, to be joined later by Company C which remained at Washington to collect and ship the stores. This work was in progress when in the autumn of 1865 my volunteer regiment was mustered out of service and I reported for duty to General Delafield. He assigned me to the charge of the construction of the fortifications at Fort Schuyler, and to the command of the Battalion of Engineers, then under that of the senior Captain, Brevet Colonel Harwood. I reminded him of General Duane's request; but he said the latter's health had suffered, and although he was in command of the Post I would be held responsible for the Battalion. Before I could assume command, I was not sorry to be ordered to report to General Humphreys for temporary duty on the Mississippi River, and it was only on June 1, 1866, that I finally took station at Willets Point.

Having long entertained the highest respect and esteem for General Duane, and feeling that our verbal instructions might cause misunderstandings as to our relative functions I had a frank explanation with him on reporting. He fully met the difficulty by at once issuing a Post order defining our relations as those existing between the Superintendent and Commandant at West Point; and from that time until the date when he was relieved from duty at Willets Point, in October 1868, we coöperated most cordially in endeavoring to make the service with troops profitable alike to the young officers who, it was understood, would be given a tour of duty at Willets Point immediately on leaving the Military Academy, and to the older officers who would find the comparative leisure useful for such professional reading as had been suggested by their experience in other fields of duty. It would be unjust to General Duane to fail to recognize the benefit I derived from his good advice in the effort, without special authority or supplies of any kind, to relieve the officers from the tedium of routine garrison life, which after the excitement of active field service could hardly fail to become irksome.

INAUGURATION OF THE ENGINEER SCHOOL OF APPLICATION.

In October, 1866, General Humphreys having recently succeeded to the command of the Corps made his first inspection of the Post. He asked many questions, and was evidently impressed with the importance not only of replacing the temporary buildings, already giving signs of deterioration, with structures better suited to the climate, but also of developing some well considered plan by which the new Post might be made to serve as a School of Application for officers and men alike, and thus contribute to the efficiency of the Corps of Engineers. The locality was well suited for the practical instruction of the troops in works of siege including land mining, in military bridge exercises, and in military reconnaissances of the surrounding country to serve as a basis for the study of defensive lines. The question for the officers was more complex, and should be developed with a view to meet the actual needs of young officers resulting from the fact that while admirably trained at West Point in the theoretical rudiments of their profession, and in many of the practical details of the military duties of all arms of service, they had still much to learn about the use and care of delicate surveying, astronomical and other instruments in constant use by the Corps of Engineers. Before the war this needful practice had often been given by early assignment to duty on the Survey of the Lakes, or on explorations for a Pacific Railroad, or for the demarkation of our International or State boundaries; but now that the first two or three years after graduation would be largely devoted to service with troops it was desirable to afford ample opportunities to master these details, without a knowledge of which maximum, anno domini 1870.6; minimum, anno domini 1878.9; maximum, anno domini 1882.4. The average number of sun spots for the last nine of these years, as reported by Prof. D. P. Todd of the Lawrence Observatory in the monthly weather reports of the Signal Service is added to the table. The "probable" auroras were estimated by assuming the same ratio on the cloudy nights as was noted on the clear nights. For 1870 only the last eleven months were included in the table, all the other years being complete.

Summary for auroral records for sixteen years.

Years.	Clear sky.		Cloudy sky.		Total for year.	Average number of sun spots.	Remarks.
	Nights.	Observed auroras.	Nights.	Probable auroras.			
1870	184	50	150	41	99	------	11 months.
1871	211	60	154	44	104	------	
1872	234	60	132	34	94	------	
1873	214	54	151	38	92	------	
1874	190	18	175	17	35	------	
1875	189	14	176	13	27	------	
1876	195	9	171	8	17	------	
1877	191	7	174	6	13	2.6	Sun spot record begun June, 1877.
1878	185	2	180	2	4	2.2	
1879	204	9	161	7	16	2.0	
1880	216	13	150	9	22	14.3	
1881	191	23	174	21	44	26.7	
1882	201	55	164	44	99	28.3	
1883	215	24	150	17	41	27.4	
1884	180	12	186	12	24	38.0	
1885	208	11	157	8	19	50.8	

It will be noted, although there seems to be no correspondence between the above number of auroras and the number of sun spots as reported by Prof. Todd, that there is a remarkable correspondence between the auroras as observed at Willets Point and the epochs of maximum and minimum sun spots as reported by Prof. Fritz. It is certain that the heavens were carefully watched by our soldiers; indeed one of the watchmen, private Thomas Murphy of Company B, discovered and reported a new comet at 2h 20m A. M., on June 22, 1881, which was in advance of any other of the numerous claims reported by the newspapers.

TIDAL AND CURRENT MEASUREMENTS.

In 1871 a systematic course of practice in tidal current measurements with double floats, electric current meters, and a self-registering tide gauge to determine the hourly water level, was begun and continued annually under direction of the Battalion Adjutant or Quartermaster. Full records were kept and discussed by the observers.

the officer was certain to find himself in respect to the civil employees of the Corps in the mortifying position of a young Infantry or Artillery officer attempting to instruct old sergeants without himself understanding the weapon. Many of the older officers had not forgotten such experiences in the days before the war, when there had been no facilities for acquiring these rudiments before actual work began. As to a post-graduate course of technical reading, it would in General Humphreys' view be inexpedient to resume at once the studies and recitations which for four years had occupied so much of the time at West Point. The young graduate should be made to feel that his school-boy days were over, and that he was now responsible for the use of the time available for reading. He had learned how to study and should be allowed to apply this knowledge in the identical manner which the duties of the Corps would exact during all the rest of his life. Any one worthy of his commission would soon begin the work, and the examinations for promotion would weed out sluggards. In a word, Willets Point should be a School of Application and not an under-graduate affair. Furthermore, as soon as means could be obtained, it should be made the special laboratory of the Corps where with the assistance of officers and enlisted men any investigations requiring experimental research should be conducted. Such an establishment had always been needed.

Such was the general plan which occupied the mind of General Humphreys and to which my local experience suggested no modification or improvement. I did, however, suggest the question whether, as some of the work that officers would be called upon to perform lay beyond the usual requirements at military posts, it might not be well to have some such official recognition by the War Department as had been given in the case of the Artillery School. He said he thought not, at least for the present. The plan would be tentative at best, and such official recognition might involve conditions that would require troublesome modifications later. The command of the Battalion carried with it the requisite authority for what was proposed, and in case of any question I could depend on his support. It seemed better to grope our way at first, until experience had indicated the best solution of the problem. Thus was inaugurated the Engineer School of Application.

At this time the roster of officers on duty with the companies was the following: Battalion Adjutant, 1st Lieut. A. Nisbet Lee; Battalion Quartermaster, 1st Lieut. D. P. Heap; Company A, at West

Point, Capt. W. H. H. Benyaurd, 1st Lieut. W. A. Jones and 1st Lieut. H. M. Adams; Company B, at Willets Point, Capt. C. W. Howell and 1st Lieut. L.C.Overman; Company C, at Willets Point, Capt. A. H. Holgate and 1st. Lieut. W. R. Livermore; Company D, at Willets Point, Capt. F. Harwood, 1st Lieut. C. B. Phillips and 1st Lieut. W. H. Chase; Company E, at Jefferson Barracks, 1st Lieut. W. Ludlow, 1st Lieut. J. C. Post and 2d Lieut. E. A. Woodruff. Many changes, however, soon occurred.

These officers had all graduated at the Military Academy during the progress of the war, and had had no experience in the civil duties of the Corps. Furthermore the Battalion organization had not been recognized by Congress, and had been improvised to meet the needs of an active field service. Graduates on reporting had usually been assigned to a Company, making the Battalion a sort of headquarters when the army was stationary, but when a movement came the demand for engineers with divisions and brigades caused so many temporary detachments that the Battalion often marched under the command of the acting sergeant major. Indeed Lieutenants Lee and Heap, appointed by me on October 3, 1866, to take rank from the date of the Act (July 28, 1866), were the first legal incumbents of the offices of Adjutant and Quartermaster. On assuming command I had found the officer of the day receiving dress parades, 1st sergeants commanding the companies. Under such conditions the summer of 1866 was naturally devoted to establishing the usual routine of duty at a military post, and to carrying out Colonel Harwood's drill orders covering infantry, pontoneering and the construction of three field batteries. One of the latter, however, was tranformed into a typical mortar battery to illustrate the system developed in the siege of Petersburg. This pattern it was found could never be silenced, by reason of overhead splinter proof shelters placed between the mortar platforms and the traverse magazines, under which the cannoneers could find instant shelter against shells exploding over the battery. The construction at Willets Point was intended as a permanent type, but was removed many years after to give place to new officers' quarters.

The instruction order for the summer of 1867, when systematic work really began, prescribed the completion of this battery, the fabrication of materials gathered in the vicinity or received from West Point into gabions, facines, etc., and the construction upon a scale of $\frac{1}{12}$ of Vauban's 1st front, Noizet's front, and the German front used at Fort Alexander at Coblenz. One of the fronts was assigned copies of a map showing the location of all sources of water supply, were early prepared and distributed; fire drills were frequently had; an old hand engine formerly famous as "Tweed's Tiger" in the days of the volunteer fire organization of New York City was purchased in March, 1867, and the soldiers were exercised regularly in its use; finally the plan of special watchmen acting with more freedom than ordinary sentinels was established for posts distant from the Guard House. An event which happened on the occasion of the funeral of General George H. Thomas in April, 1870, illustrated the good judgment of one of the young officers, Lieut. Powell, Battalion Quartermaster. The troops were ordered to Troy to form part of the escort, and I left him in command of the Post, with only a few men to guard the property. Reflecting that the usual fire measures could not be carried out from want of men, the first thing he did was to have all available buckets filled with water, and to arrange a signal for all hands to assemble on the run. A few moments after these arrangements were perfected the cry of fire came from a building occupied as the Adjutant's office, situated on the line of officers' quarters. The stove pipe where it passed through the roof had ignited it. The signal was given; the men assembled, laughing at the supposed drill alarm; and the Post was saved from destruction, for the wind was strong and once started nothing could have stopped the flames.

In 1868-69 the Battalion did much experimental work for an Engineer Board appointed to prepare, in the form of a Ponton Manual, a revised system of bridge equipage and drill, which should embody the practical experience of the War. After its adoption, the manual work of remodeling many of the old wagons to make them conform to the adopted pattern was continued for several years by skilled carpenters from the Companies.

In 1870 the functions of the Depot were extended to include the inspection, repairs, and issue on approved requisitions of the instruments held in reserve for the use of the Corps. For their safe storage a fireproof brick building was finally erected. Some of them soon began to suffer from the condensation of moisture in the damp air of the seacoast, and an experiment on a large scale was made with calcium chloride (not chloride of lime) to artificially dry the room where the most delicate of them were stored. It had 37,000 cubic feet of air space. The crystals were exposed on gratings which allowed the fluid caused by the absorption of water to drip into reservoirs. This fluid was subsequently evaporated by boiling, and the

TORPEDOES DONT ANCHOR

salt was thus recovered, to be used again. By noting the weight before and after boiling, the volume of water taken from the air of the room could easily be determined. During the year 1880-81 by six boilings each six hours long 74.7 gallons were thus removed: in 1881-82 seven boilings yielded 85 gallons; and in 1884-85 the volume was 107 gallons. The result was a decided success, and suggests how some damp powder magazines may be rendered dry at little expense.

THE SUBMARINE MINING SERVICE.

But the most important researches conducted at Willets Point during my tour of duty there were those connected with submarine mining. In May, 1869, General Humphreys, with the sanction of the Secretary of War, devolved upon the Battalion of Engineers the duty of developing a torpedo system, as an accessory to the permanent seacoast defences of the Country. The work was to be done under the direction of the Board of Engineers, of which the commanding officer was made a member when this subject was under consideration. The problem involved experimental researches with all known kinds of modern high explosives to determine their relative intensity of action, and the laws governing the transmission of the shock of explosion through water; the best form of cases, modes of anchorage, and typical grouping of mines to insure the blocking of a channel of approach; the best mode of operating the mines so that while innocuous to our own fleet they should be deadly to an enemy; in a word, an elaborate experimental study of a new and little known element of modern warfare. Work was immediately begun and continued without interruption during my entire tour of duty with the Battalion, resulting in developing a complete system which received the approval of the Government.

To determine the relative intensity of action of different explosives, and the laws of its transmission through water, use was made of wrought iron rings having interior diameters ranging from 3 feet to 8 feet, and carrying six pressure gauges disposed around a central charge to be tested. The method heretofore in use for forming the scales for these gauges by static compression proved to be inapplicable when they were subjected to the sudden blow given by a high explosive, and a new method by impact was devised which solved the difficulty. The rings were supported vertically at any desired depth by cylindrical buoys floating vertically, with pointed bottoms reducing the shock to the minimum. The whole apparatus was often thrown bodily into the air with the jet. It was manipulated from a raft made by connecting two pontons, and provided with a windlass for raising and lowering the ring. To extend the measurements to longer ranges, a large wrought iron crate, fifty feet by ten feet by ten feet, was constructed. The stresses were reduced to the minimum by making it of half-inch plates from 5 to 11 inches in width, the planes of which passed through the central point to be occupied by the explosive. Each of the nine cross frames carried four pressure gauges. The whole was supported, either horizontally or inclined at any desired angle or depth, by two cylindrical buoys with wire rope slings attached to cross frames diagonally braced. This apparatus was maneuvered by a sixty-ton schooner towed to the firing station by a small steam launch. Here the crate was abandoned to its buoys; the charge was fired by electricity; the schooner returned; the crate was raised; and the pressure gauges were recovered. Many large charges of different high explosives were fired in this manner, the last one, 100 pounds of dynamite No. 1, fired in 1878, disrupted the crate, but the gauges were recovered. An analysis of these ring and crate records revealed the algebraic law governing the transmission of intensity of action through the fluid, together with the relative efficiency of about a dozen explosives, of which two, the safety compound and dualin, proved to be too dangerous for service. In 1879 dynamite No. 1 was definitely adopted as the best known explosive for our submarine mines. This conclusion was not reached without a long series of experiments upon sympathetic explosions, which demonstrated that their range was too short for one explosion to endanger neighboring mines as planted for service; and also that, if not compacted into cartridges, the dynamite when thoroughly frozen was certain to be detonated by our adopted fuze.

During the progress of the above experiments investigations had also been conducted to determine the intensity required to disrupt the bottom of a modern ship of war. A target representing the latter in interior construction, 20 feet by 20 feet by 3 feet in dimensions, was placed in position and held firmly down by several 1,000 pound anchors and chain cables crossed over it. Various charges of dynamite No.1, ranging up to 200 pounds, were supported under it at different depths and exploded by electricity. These researches made known the proper charges and their dangerous ranges, whether floating or resting on the bottom.

The formulæ resulting from these researches were tested during the exceptionally cold winter of 1878-79 by many explosions under thick

ice. The intensity at the edge of the circular crater produced by the explosion of a dynamite cartridge inserted through a small hole, was compared with those resulting from much larger charges at greater depths. The formulæ uniformly indicated like intensities at these points, thus confirming their trustworthy character.

In 1878 the old schooner that had been used to maneuver the crate was blown up, to illustrate the nature of the strains of a sub-aqueous explosion upon a vessel. Six cameras were employed to record the result. Their exposures were regulated by the explosion of electrical fuzes fired from a key board, the same circuit recording the exact time on a chronograph. The first view, taken at the instant when the mine exploded, shows the vessel lifted high amidships, with bow and stern depressed. This phase passed so rapidly that the eye failed to distinguish it. The maximum height of the water jet (180 feet) was reached in 2.3 seconds, showing the air full of fragments. In 4.3 seconds only a cloud of mist and smoke remained over the wreck. At this date the dry plate process had not been introduced and these highly successful pictures taken by the wet plate process reflect great credit on the photographic detail. Another sample of good photographic work was secured about this same date. A condemned mule was killed by exploding a cartridge of dynamite behind his ears. The exposure of the plate was caused by the explosion of a second fuze in the same electrical circuit. The picture showed the animal still standing, with his front legs slightly bent but with his head detached and hanging by a strip of skin against his breast.

The best kind of electrical fuzes for igniting the mines was determined by a long series of experimental investigations involving novel apparatus. Both high tension and low tension varieties were included.

The kind and shapes of torpedo cases and anchors received like attention, including resistance to blows from the largest class of steamers navigating Long Island Sound, moving at full speed, and actual submergence through a full period of five years. A knowledge of the degree of buoyancy necessary to prevent too much depression by strong currents was obtained at Hell Gate, in 1874, by a series of elaborate measurements, over 400 in number. A large scow was anchored bow and stern in 50 feet of water. Torpedoes of different shapes were held down by their anchors nearby. Graduated lines supported by fishing poles rose from their top rings, allowing the exact depression from the vertical to be noted at any instant. The velocity of the current, ranging at different stages of the tide from zero to five miles per hour, was measured by three independent methods and the corresponding depressions were read on the graduated lines. These data made known the constants of the desired depression formula. Such were the investigations which determined our adopted patterns of submarine mines.

At a later date a device was perfected by which either buoyant or ground mines, while quite safe to handle, would automatically become dangerous a few moments after submergence.

After trials of various experimental devices, the final patterns of circuit closèrs, batteries, testing apparatus, operating boxes, etc., were perfected, and a definite system for disposing the mines in grand groups or skirmish lines was adopted in 1874. The operating boxes included an arrangement by which the fire of guns previously pointed to sweep the lines of mines would be provoked at any locality by an attempt there at countermining. At this date 600 miles of torpedo cable and 300 mines had been procured; a new Torpedo Laboratory for officers and a building for the instruction of the enlisted men had been completed; a preliminary Manual had been issued in the form of a Battalion Order dated December 10, 1873; and the Board of Engineers had taken up the study of detailed projects for the defence of the harbors of the United States. In a word submarine mining passed at about this date from the field of investigation to that of practical application, in this country.

But it must by no means be inferred that researches in this direction were not actively continued. The Smith movable torpedo driven by ammoniacal gas and steered from the shore by electricity had early been the subject of practical trials at Willets Point. It was succeeded by the Sims fish torpedo, driven and steered by electricity from the shore, with which many elaborate trials were made involving accurate tracking by triangulation at intervals of a few seconds, and complete records of the power developed at the dynamo and expended at each point of the run. These trials called for the coöperation of nearly every officer at the Post, and of many of the enlisted men. Sufficient success was had to cause the purchase of a few of the torpedoes to place in store. At this date the electrical transmission of power was in its infancy, and few experiments in this country antedate these researches at Willets Point.

It is pleasant to remember that during these investigations the most cordial relations existed between ourselves and the Naval Torpedo School at Newport, then in charge of Commander E. O. Mathews.

Visits were often exchanged, and any new ideas were mutually communicated.

Experiments to develop the utility of electric light projectors for protecting mine-fields against countermining were conducted in the early days at Willets Point, when the use of this kind of light was so new as to attract many spectators. The first projector was a silvered parabolic reflector, served by from 50 to 200 Grove cells. Later an Alliance magneto-electric machine was used, and then a more modern dynamo, with a glass lens of the form used by the Light House Board but computed for the electric light. The conclusion was reached, in 1874, that this accessory in the defence of mine-fields is very useful in clear dark nights, of comparatively little value in bright moonlight nights, and of no value in fogs. Also that the observer must be at a considerable distance from the lens.

The proof edition of the Submarine Mining Manual was completed and printed on the Battalion press in 1877. This, after testing by practical use, was replaced by a new edition formally adopted by the Department, to which I put the last touches after being relieved from duty at Willets Point in 1886.

As the defence of the seacoast by submarine mines, assigned to the Corps of Engineers by Congress, involved study in several branches which hardly formed part of the curriculum at West Point, a new question was early presented as to the best mode of certainly making the young officers proficient in this duty. At first they were put upon a roster and detailed weekly by twos for such assistance as might be required, and to spend at least six hours daily in the laboratory, making use of the library and instruments for personal study of electricity, modern explosives, etc. No recitations or examinations were required. Finding from the examinations for promotion that in a few cases this plan was not entirely successful, a change was announced in the Instruction Order of November 9, 1882. The three Captains were constituted, under the Commanding officer, a Board of Instruction. They were individually to take military charge, for one week in turn, of the buildings and details of officers and enlisted men, and to direct the courses of reading, experiments and drills. The student officers were divided into two classes according to their periods of service with the troops. Semi-annual examinations before this Board (four for each officer) were prescribed; and a regular programme for each of them was laid down. This plan worked well, and it is believed was equally effective and less onerous for the officers than would have been recitations and marks. As this important Battalion Order, and indeed the entire series subsequent to July, 1879, are to be found in print in the Annual Reports of the Chief of Engineers, no further details are needed here.

It is a little singular, but is nevertheless a fact, that the establishment was officially recognized as a Torpedo School prior to its recognition as an Engineer School of Application. General Sherman, who often visited Willets Point and took great interest in the researches in submarine mining, issued the following order through the Adjutant General's Office on August 30, 1880.

"When the number of subaltern officers absent from any of the artillery regiments does not exceed eleven, the commanding officer of such regiment is authorized, with the approval of the department commander, to order one subaltern to Willets Point, New York, January 1st of each year, to serve six full months, to receive instruction in torpedo service."

Under this order a class of Artillery officers annually took the course in submarine mining under the conditions prescribed in Battalion Order of January 3, 1881, which gave them in all respects the same advantages as the Engineers. During my tour of duty these officers were:

Class of 1881—1st Lieut. E. L. Zalinski, 5th Artillery; 1st Lieut. J. E. Eastman, 2d Artillery; 1st Lieut. A. H. Merrill, 1st Artillery.

Class of 1882—1st Lieut. W. P. Edgerton, 2d Artillery; 2d Lieut. J. C. Bush, 5th Artillery.

Class of 1883—2d Lieut. J. L. Chamberlain, 1st Artillery; 2d Lieut. H. A. Schroeder, 4th Artillery; 2d Lieut. M. C. Richards, 2d Artillery.

Class of 1884—1st Lieut. I. T. Webster, 1st Artillery; 2d Lieut. W. P. Newcomb, 5th Artillery; 2d Lieut. O. M. Lissak, 4th Artillery; 2d Lieut. J. T. Thompson, 2d Artillery.

Class of 1885—1st Lieut. H. H. Ludlow, 3rd Artillery; 2d Lieut. C. P. Townsley, 4th Artillery; 2d Lieut. H. C. Carbaugh, 5th Artillery; 2d Lieut. S. Rodman, Jr., 1st Artillery.

Class of 1886—1st Lieut. Allyn Capron, 1st Artillery; 2d Lieut. C. G. Treat, 5th Artillery; 2d Lieut. I. N. Lewis, 2d Artillery.

Upon the completion of the course a report was made to the Commanding General of the Army, giving for each Artillery officer the opinion of the Board of Instructors as to his absolute fitness for detail in case of war, indicated under one of four grades, viz:

competent to plant and operate, competent to operate, competent as an assistant, or deficient. No classification as to relative proficiency was made in these reports.

For the instruction of the enlisted men in submarine mining, a systematic course was early inaugurated. At first an old carpenters' shop, subsequently replaced by a fine new building, was used as a laboratory for instruction in loading torpedoes, charging junction boxes, making joints in electric cables, operating the dial telegraph, and many other details of the service. During the summer season the soldiers were practiced in planting and raising mines; in firing them; in the boat service generally, making use for the latter of pontons, ponton rafts, a small steam launch, and finally of a fine new steamboat (for description see page 51, Annual Report of Chief of Engineers for 1886), designed specially for the purpose and named the David Bushnell, in memory of the pioneer in the use of sub-aqueous explosions for the destruction of shipping, who was a Captain of Engineers in the army of the Revolution. Instruction in this branch of the school was directed by the officers of the weekly torpedo detail, aided by sergeants who had become experts in the duty. Officers of that day will remember in this connection Sergt. Conklin, Sergt. Nolty, Sergt. Kelly, Sergt. Warner and Sergt. Brown.

SPECIAL RESEARCHES AT WILLETS POINT.

The first work of this kind was done in August, 1867. The introduction of armor and heavy guns on ships of war had raised many new questions as to the planning of works for coast defence. General Totten had always favored low sites, to secure the maximum advantages of ricochet fire. The new conditions suggested higher positions for the batteries, to be armed with 15-inch guns, and the problem arose to determine to what extent this involved a reduced length of ricochet trajectory dangerous to shipping. Observations to settle the question began on the Potomac in the summer of 1865, and were terminated by the officers of the Battalion in August, 1867, the firing being done for us by the artillery garrison at Fort Schuyler. The results in detail are given on pages 57-84 of No. 14, Professional Papers of the Corps of Engineers.

At the time when experiments with explosives was begun at Willets Point the use of low tension fuzes was not common in economic blasting in this country. The market was stocked with high tension varieties, ignited by a spark given by a class of machines of which that known by the name of the inventor, Mr. H. Julius Smith, was most common. The spark passing between terminals bedded in fulminating copper determined the explosion. The extreme sensitiveness, and hence the dangerous character of these fuzes, will be understood when it is stated that they could be ignited by passing an ebonite comb a few times through the hair of a child standing on an insulating stool, and holding one end of a leading wire the other end of which was attached to one terminal of the fuze, the other terminal being in the air. Accidents were common, and the matter demanded attention. An extremely delicate form of electrometer was devised by which sparks of known and regularly increasing quantity could be successively sent through the fuze until its detonation indicated the minimum necessary. By the aid of this machine and the coöperation of Mr. Browne, a fuze manufacturer, a reasonably safe priming, known later as Browne No. 4, was discovered and used for a time in our experiments. He put it upon the market, and supplied large numbers to the Hoosac Tunnel, where it probably saved many lives. These researches are reported in detail in No. XLVII of the Essayons Club series. At this same time General Newton was conducting the preliminary operations for the great blast at Hallets Point, and narrowly escaping a terrible accident with one of the dangerous varieties, he took great interest in our researches at Willets Point, supplying me with samples of all his fuzes for test. This continued even after we had both of us adopted the low tension platinum wire fuze; and I was thus naturally led to study his special problem for the great blast, which demanded the firing simultaneously and with absolute certainty an immense number of fuzes. A paper giving the results of my analysis was read before the National Academy of Sciences on April 18, 1876, and it forms No. XXXIX of the Essayons Club series. General Newton used the formulæ in arranging his circuits for the great blast of September 24, 1876 (3680 fuzes), and again in that of Flood Rock in 1885 (591 fuzes), and with a success that left nothing to be desired. A conspicuous failure at a large private blast near Albany, a few months after the former, illustrated the importance of mathematical treatment in such problems.

General Humphreys, who always took interest in scientific investigations, appreciated the opportunity afforded by the explosion of about 50,000 pounds of dynamite at Hallets Point; and as General Newton had no facilities for measuring the velocity of transmission of the earth wave, assigned the duty to the Engineer Battalion. Delicate mercury seismometers were improvised at Willets Point, the

coöperation of the Western Union Telegraph Company was secured, and the velocity was measured over a range of about 13 miles. Full details were read before the National Academy of Sciences on October 18, 1876, and may be found in No. XL of the Esasyons Club Papers.

The velocity of transmission proved to be about one mile per second, which so much exceeded that found many years before by Mr. Mallet from small gunpowder explosions in England that the investigation was continued at Willets Point, by taking advantage of the frequent firing of torpedoes ranging from 70 pounds of gunpowder to 400 pounds of dynamite. The results were published in the American Journal of Science for March, 1878. They suggested the following conclusions: "(1) A high magnifying power of telescope is essential with mercury seismometers. (2) The more violent the initial shock the higher is the velocity of transmission. (3) This velocity diminishes as the wave advances. (4) The movements of the earth's crust are complex, consisting of many short waves, first increasing and then diminishing in amplitude; and, with a detonating explosive the interval between the first wave and the maximum wave at any station is shorter than with a slow burning explosive."

At the much larger explosion at Flood Rock, on October 10, 1885, the Battalion was charged with observations covering a wider range. The exploding charge consisted of 240,399 pounds of rackarock, having an intensity not inferior to that of dynamite No. 1, and of 48,537 pounds of the latter added to insure the full detonation of the former, and to reduce by sympathetic explosion the number of fuzes to be simultaneously fired. General Newton in his report states; "The specifications required that the rackarock should have a strength only of 90 per cent that of No. 1 dynamite when fired under water and measured by the method in use at the Engineer School of Application at Willets Point. But such care was taken by the contractors in selecting their materials and such benefits derived from the careful determination made at Willets Point experimentally, and from the analysis of the exact proportions of oil and chlorate to be used, as well as the thoroughness of the mixing of these ingredients, that the 71 samples tested showed an average strength of 109 per cent that of dynamite No. 1, no sample falling below 99 per cent."

At the explosion the whole Battalion was on duty. Captain Bailey was charged with determining the exact instant of explosion, in 75 meridian time, to render available time records of volunteer observers. Captain Knight experimented with three novel types of seismographs set up at Astoria. Lieut. Lusk directed the taking of photographs at the firing point to determine whether the explosion was simultaneous in all the galleries. Three parties stationed along the telegraph line on Long Island and one at West Point received on their chronographs each tick of the standard break circuit chronometer at the firing station, and also when the mine was fired a signal made by the same motion of the firing key that caused the explosion. The local records of arrival and duration of the earth wave were also recorded on the same chronograph sheet. Thus the instant of explosion and the instants of arriving and ending of earth movements at each station were registered in the time of one standard chronometer. This plan was an improvement on that used at the Hallets Point explosion, by which only the interval of time between the igniting of the charge and the arrival and ending of the tremor at each station was registered on the chronographs. By adding the ticks of the standard chronometer provision was made for referring everything to the same absolute time, permitting comparison to be made with the records at several outlying stations, off the line of the telegraph, but where the true time was known from local astronomical observations. Such stations were Willets Point, Goat Island, and the observatories of Harvard College and Hamilton College, the latter extending the range of observation to a distance of about 175 miles from Flood Rock. At Willets Point not only was a mercury seismograph used but also as a check a Thompson reflecting galvanometer so adjusted as to be specially sensitive to local tremors.

My report to General Newton (page 691 of the Annual Report of the Chief of Engineers for 1886) fully covers the details of these investigations not only for the two great explosions but also for the similar special observations at Willets Point. It is therefore enough to state here that the earth wave at the Flood Rock explosion moved northward through rock at a velocity of nearly four miles per second, and eastward through the drift formation of Long Island at a more variable rate but nowhere exceeding about three miles per second. The Flood Rock charge was about six times as great, and the rate of transmission about three times as great, as those noted at the Hallets Point explosion.

MILITARY PEACE RECORD OF THE BATTALION.

On December 3, 1869, the Battalion was ordered with other troops to Brooklyn to support the Collector in suppressing some illicit distilleries near the Navy Yard. This duty was performed in a way to receive the official thanks of the Commissioner of Internal Revenue, communicated through the Department Commander.

Again, on November 3, 1870, the Battalion was ordered to Brooklyn on like duty.

In the same year the Battalion was ordered to New York City and, with other troops from the forts, was held in reserve to suppress anticipated election disturbances, which, however, did not occur.

In the great Railroad Riots of 1877 the Battalion took an active part, with all available regular troops. It proceeded to Baltimore on the night of July 1st, and while en route to relieve one of the regiments of the National Guard at its armory had a soldier in ranks knocked senseless by a brick thrown by a rioter. The incident had a ludicrous ending. The Battalion was marching in column of Companies, and Captain Livermore seeing his men likely to trample on the fallen soldier commanded "Halt" in so loud a tone that the entire Battalion obeyed the order. Marching at a right shoulder the men naturally came to a carry, and did it so perfectly in unison that the mob which crowded the street mistook it for the first movement of firing. A wild panic instantly occurred. Men rushed in every direction, one plunging head first through a window into a neighboring house. The street was effectually cleared, and we had no further annoyance in reaching the armory. On July 26th the Battalion was transferred to Philadelphia, and on August 2d to Easton, Pennsylvania, where it remained in camp until August 17tn, when it was ordered back to Willets Point. General Hancock officially commended its services in the following letter, signed by his A. A. Adjutant General:

"I am directed by the Major General Commanding the Division to say, that, orders having been issued relieving you from duty in the field, he takes the occasion to tender to you, and the officers and soldiers of your Battalion, his thanks for the soldierly manner in which all have preformed the arduous and delicate duties assigned them during the recent disorders. He further instructs me to say that the bearing and discipline of the Battalion have been admirable throughout, and that the services rendered by it deserve the highest commendation."

Such commendation from a soldier of General Hancock's record can hardly be appreciated too highly.

At the explosions at Hallets Point and Flood Rock the Battalion was called upon to preserve order and guard the public property, and it received the thanks of General Newton for the "prompt and efficient" manner in which it was done.

The Battalion formed part of the escort of regular troops at the funerals of General Thomas and of Admiral Farragut, and held the right of the line at that of General Meade, its old Commander whose Headquarters it had so often followed in the Civil War.

The Battalion took a prominent position in the regular service when the establishment of the rifle range at Creedmoor, in 1873, attracted general attention to this important element of military efficiency. The order of the War Department prescribing the system of instruction in markmanship laid down in Heth's Target Practice, and carried into effect by Battalion Order of March 23, 1867, had been scrupulously obeyed, and the men were already experts in shooting the rifle. The results of this practice, with the names and strings of the Company and Battalion prizemen, had been annually announced in orders since 1867. Indeed in 1869 the annual Army target prize, a large silver medal, had been awarded, it is believed for the first time, to private J. W. Miller of Company E. This prize had been open for competition to the entire army since 1862.

Individual and team practice at Creedmoor by our officers and men began soon after the opening of the range in 1873. In the first thirteen years, at the regular Spring and Fall Meetings, 117 individual prizes were won by them, using the Springfield rifle often in competition with sporting arms. Many team matches were also shot during this period, of which the following are the most noteworthy.

The Short Range Military Team Match.—Open to teams of five men duly certified to be members of the Company they represent in any organization of the National Guard of any State, or of the Regular Army, Navy, or Marine Corps. Distance 200 yards; position, standing; rounds, seven. The prize was a handsome embroidered flag, to be held by the winner for one year, and to become a permanent trophy after being won three times by the same organization. This was sharply contested for eight years, by about a dozen competitors. During this period it ornamented the barracks of Company B twice, of Company C twice, and in 1883 it became the permanent trophy of the latter.

The Army and Navy Journal Match.—Open to teams of twelve from all regularly organized military organizations in the United States. Their own uniform to be worn, and their own rifle to be used. Distance 500 yards; rounds, seven. This prize, too, was to be won three times before becoming the property of the winning organization. It was shot for ten times, and was sharply contested often by nearly

twenty teams. It was won in 1878 and again in 1881 by the Battalion, but was finally lost, in 1883, to the 7th Regiment of New Jersey National Guard, which had about 900 men to draw upon for its team while the Battalion had only about 150.

The Company Match.—Open to the National Guard and Regular Army. Teams of five men; distance 200 yards; match shot June 3, 1879; 8 competiting teams. Company C of the Battalion took 1st prize; Company B, 2d prize; and Company A, 3rd prize.

The Military Team Match.—Open to the National Guard and Regular Army. Teams of four men; distance 500 yards; match shot on same day as last; 6 competiting teams; two from the Battalion won 1st and 2d prizes.

The Skirmishers' Match.—This novel match was shot at the Fall Meeting in 1881. It was open to members of the Army, Navy, Marine Corps, and to the National Guard, Volunteers, or Militia of any country. Each competitor to advance from the 600 to the 200 yard range and return, making five halts in each passage. Twenty rounds were allowed to each man, and elaborate rules were prescribed for their use. Many soldiers competed, and the prize was won by private John Cavanagh of Company C. In transmitting it Major General Hancock, as President of the National Rifle Association, wrote to me:

"I send you herewith the 'Traver's Badge,' the first prize in the skirmishing match at Creedmoor—which was won by private John Cavanagh of your command.

"This match is one in which I take a special interest, as introducing a new departure in rifle matches. * * * It was my desire to show my appreciation of this match by presenting personally this badge at the close of the contest, but I regret I was unable to do so.

"I, therefore, transmit the badge to you with the request that you will present it to private Cavanagh, its winner, in front of his battalion, and in so doing convey to him and to his officers and comrades my congratulations upon his success, as well as the pleasure I feel in seeing that the Army is able to show that it can hold its own in practical military rifle shooting."

Under the competitions for the Nevada Trophy, prescribed in General Order No. 45 from the Headquarters of the Army, dated May 11, 1881, Company C of the Battalion took second place in 1881 and third place in 1882, the firing being open to all companies and batteries of the entire Army.

Under the provisions of General Order No. 53 Headquarters of the Army, series of 1882, establishing competitions for Department, Division and Army prizes for markmanship, the Battalion of Engineers had the distinguished honor of sending a marksman and alternate to report to the Commanding General of the Department of the Missouri to form part of the Army team of twelve soldiers selected by competition for the competition at Fort Leavenworth, in 1882. Sergt. Charles Barrett of Company B was selected to represent the Battalion, with Corporal Doyle of Company A as alternate, after careful competition at Willets Point. The match, at ranges of 200, 300 and 600 yards, was shot on October 25, 26, 27, 1882, and Sergt. Barrett won the first prize, a large gold medal, which he received from the hands of General Sherman. Thus did the Battalion a second time win the prize for markmanship open for competition to the entire army.

Sergt. Barrett was sent again in October, 1884 to compete at the bi-annual Fort Leavenworth match for the Army prize. There were twelve competitors and he won the fourth of the six prizes, a large silver medal presented in person by General Sherman. Shortly after, at a special prize match offered by the citizens of St. Louis to the six winners of the Army prizes, Sergt. Barrett won the first prize.

The foregoing military peace record of the Battalion makes it evident that, although much time and attention are given to matters forming no part of the training of other troops, the military efficiency of the soldiers is by no means impaired thereby. Neither officers nor enlisted men have ever failed when brought to this test.

END OF TENTATIVE DEVELOPMENT.

It will be appreciated from what has gone before that the development of the Engineer School of Application was a very gradual process. To furnish the officers with every possible facility for perfecting themselves in a knowledge of the practical duties of the Corps, had been kept steadily in view, and an advance had been made as rapidly as the means at hand would permit. A fairly good library had at last been secured; and a valuable collection of models illustrating bridges, ponton trains, military mining, river improvements, harbor improvements, and other engineering works had been accumulated, partly by utilizing the labor of skilled artisans in the Battalion, and partly by soliciting contributions in kind from officers of the Corps directing important public works. General Wright who had succeeded General Humphreys as Chief of Engineers, and whowas perfectly familiar with the conditions at Willets Point, considered at length that the time had come for a more formal recognition of the establishment, and early in 1884 he called upon me for a succinct statement of the conditions existing at the School of Application. The following letter was written in reply.

BATTALION OF ENGINEERS,
WILLETS POINT, WHITESTONE P. O.,
QUEENS COUNTY, NEW YORK,
February 6, 1884.

GENERAL H. G. WRIGHT,
CHIEF OF ENGINEERS, U. S. A.

GENERAL: In reply to your instructions of the 28th ult., I have the honor to submit the following statement of the course of practical and theoretical instruction adopted and now carried out at Willets Point, for graduates of the U. S. Military Academy assigned to the Corps of Engineers.

It is proper to premise that the School of Application, during the past 17 years, has gradually developed from an ordinary military Post to its present organization, and that progress has by no means ceased.

At the end of the War the Battalion of Engineers was ordered here from the field, to garrison and construct a new Post, and establish a depot for the bridge equipage and stores of Engineer material on hand. No permanent barracks or storehouses existed, and use was first made of the temporary buildings erected for the Grant General Hospital. The company officers of all grades had been graduated during the war and consequently had no experience in any of the civil duties of their Corps. At the outset every one was fully occupied in remodeling the buildings, in storing the material, and so far as time would permit in Engineer and Infantry drills. In a word, Willets Point differed in no essential particular from the other military Posts of the Army.

Shortly after his appointment as Chief of Engineers in 1866, General Humphreys inspected the establishment. He seemed to be impressed with three ideas: (1) That to command and properly instruct the companies a considerable detail of officers of the Corps would be permanently needed. (2) That this service should be apportioned among all the officers in turn, thus giving them that practical experience with troops which the war had convinced every one was desirable. And (3) that, for the young officers, the duty should be combined with facilities for supplementing theory, which time alone permits at West Point, with the practice needful to make the knowledge available in the actual works intrusted to the Corps of Engineers. For various reasons he did not consider it advisable to publish any general order on the subject; but in a personal conversation he instructed me under my own authority as Battalion Commander to require such professional exercises both civil and military as the facilities at hand would permit, informing me that, as a rule, the tour of duty for Captains and Battalion Staff officers would be about four years, and that immediately after graduation at the Military Academy the young officers would all be sent here for about two and a half years before assignment to other duty.

The general system thus inaugurated in 1866 has been carried out as closely as circumstances would permit up to the present time. Very little money has been available; but the steady support of the Chief of Engineers, and the interest and coöperation of the officers of the Battalion, have rendered it possible to overcome many difficulties; and, in my judgment, the School of Application now supplies a need of which every officer of the Corps was sensible before the war.

I shall not attempt to trace the gradual advance, which is sufficiently indicated by the file of Battalion Orders and by my annual reports. The following is the present status of the School.

The three Captains, in addition to the military command of their companies, are each charged with special branches of instruction, and, together with the Battalion Commander, constitute a permanent Board of Instructors. The Battalion Staff officers (usually 1st Lieutenants of several years' experience) also act as instructors in certain branches, in addition to their regular military duties. The recent graduates are attached to the companies, and beside the ordinary routine of a military Post, which is strictly enforced, enjoy many advantages for becoming familiar with various branches of civil and military engineering. The enlisted men are instructed both theoretically and practically by their Company officers.

The course is divided into two parts, winter extending from December 1st to April 30th, and summer covering the rest of the year. The first is chiefly in laboratories, and is somewhat theoretical in character; the last includes, also, exercises and practice out of doors.

By persistent effort the School has finally become well provided with apparatus. We now have a fine electrical and torpedo laboratory; a very convenient photographic laboratory; the best field astronomical observatory I have ever seen; a museum containing valuable models both military and civil; a new modeling room (now under construction to replace the old one) for moulding in sand on a scale of $\frac{1}{6}$ every kind of field fortification, including parallels and saps; a good range for target practice, with a room for gallery practice in the winter; an ample supply of surveying instruments, a self-registering tide gauge, current meters, &c.; and finally the nucleus of a professional library. So soon as practicable a small building will be erected for magnetic and meteorological observatories (the present one is not suitable), and a shed for practice with base measuring apparatus.

Perhaps the best way to explain the system of instruction is to indicate the duties of a young graduate from the time he joins the Battalion from West Point, until he has completed his first tour. (Most officers of the Corps return again as Captains and sometimes as Staff officers).

The new officers usually report from West Point early in October. The first two months are spent in becoming familiar with routine military duties, including practice with the sextant for regulating the Post time when officer of the day. These military duties of course continue during the whole period of service with the troops.

The first winter course (five months) includes 14 weeks of study in the Torpedo Laboratory, with two examinations before the Board of Instructors (January 31st and April 30); these examinations continue about five hours and cover the whole of the Torpedo Manuăl, in prescribed portions; 8 weeks of study and practical work in the Photographic Laboratory; two consecutive days of hourly meteorological observations, with the study of Colonel Williamson's report upon barometric hypsometry and the reduction of a part of the whole series (60 days' observations) made by the officers and non-commissioned officers; and lastly the conducting of some of the recitations of the non-commissioned officers of his Company, under the direction of the Captain.

The first summer course (7 months) includes frequent weekly details (fixed by number of officers for duty) for torpedo practice on the water and in the Labaratory, and for aiding the Battalion Commander in the investigations in submarine mining in progress; systematic instruction in practical astronomy, covering the use of the astronomical transit and zenith telescope, the sextant upon stars for time and latitude, and the personal equation machine—the extent of this work may be inferred from the fact that the observatory is in use on every pleasant night from May 1st to December 1st; the survey of one square mile of ground, including transit and stadia work and contours with the spirit level; the making of foot reconnaissances with pocket compass and hand level; and, under the direction of the Captain, the instruction of the enlisted men in Infantry drill, target practice, military reconnaissance, the use of the railroad transit, field fortification in the moulding room, ponton drill on land and on the water, and sometimes in military mining on land. The reduced force of the Battalion renders some of these drills unsatisfactory at present, and deprives the officers at well as the men of much valuable experience.

The second winter course includes 7 weeks in the Torpedo Laboratory, with two examinations before the Board of Instructors (January 30th and and April 29th); these examinations are each about five hours long, and cover the investigations in submarine mining made here during the past 15 years, and a study of all foreign systems and experiments so far as known; 8 weeks of study and practical work in the Photographic Laboratory, thus completing the course, which covers making negatives with gelatine emulsion plates, silver printing, map printing including glass and paper negatives, the blue process, etc., photo-lithography, heliotype process, &c.; two consecutive days of hourly meteorological observations and reductions, as before; and lastly aiding in conducting the Company recitations, as before.

The second summer course includes the frequent weekly details for torpedo practice, as before; instruction in practical astronomy completed, including the use of the latest patterns of combined transit and zenith telescope instruments, and of the 5.5 inch equatorial telescope; tertiary triangulation and hydrographic work, with current measurements and the use of the self-registering tide gauge; and the instruction of the enlisted men in their various drills and exercises, as before. So soon as the necessary buildings can be prepared, practice in field magnetic observations and in the use of the Repsold base apparatus will be included in this summer's work.

The third winter course includes 7 weeks in the Torpedo Laboratory, devoted to such reviews and investigations as the officer may select for himself, and in daily lectures and instruction to the enlisted men, under the Captain in charge—no examination is required; the meteorological observations as before; the preparation of drawings and a memoir upon some prescribed problem in permanent fortification or in the operations of an army in the field, which after revision and discussion by the Board of Instructors in the presence of the officer is transmitted to the Chief of Engineers; and finally the aiding in the Company recitations, as before.

The tour of the officer at Willets Point is supposed to terminate about May 1st, when the opening of the season creates a demand for assistants on the several works.

It may be added that in the fortifications at Fort Schuyler and Willets Point a fine opportunity is afforded to study in detail the development at all marked epochs during the past fifty years.

In conclusion, I would invite attention to three points, which in my judgment are of no little importance to the success of the School of Application. (1) The young officers should always complete their regular tours. (2) The Captains and Battalion Staff officers should be relieved by their successors before quitting the Post. They all occupy responsible positions which cannot be left vacant without more or less confusion. (3) The number of our enlisted men, as now authorized, is not only wholly inadequate to meet the needs of the Country should it become necessary to defend the coasts with torpedoes, or to put an army into the field, but is also insufficient for the preparatory instruction of both officers and men in their special military duties. The whole three Companies, recruited as they now are to only one-third of the organization fixed by law, cannot perform the ordinary guard and police duties of a Post like this and at the same time furnish enough men to properly construct a military bridge, to make a land mine or field fortification in any reasonable time, or even to permit of a satisfactory battalion drill.

Very respectfully, your obedient servant,

HENRY L. ABBOT,
Lieut. Col. of Engineers, Bvt. Brig. Gen., U. S. A.

General Wright was retired from active service in March, 1884, before taking further action in regard to the School of Application. The Secretary of War, Hon. Robert T. Lincoln, visited the Post in July, 1884, in company with General Newton who had succeeded General Wright, and he was so much impressed with what he saw that he immediately authorized an increase of 250 men in the garrison, thus raising the effective strength of the Engineer Battalion from 200 men to 450 men. General Newton was also authorized to call upon the Board of Engineers for a report looking to a formal recognition of the School of Application by the War Department. The following document makes known the result.

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY, WASHINGTON, D. C.,
February 20, 1885.

HON. ROBERT T. LINCOLN,
SECRETARY OF WAR.

SIR: I have the honor to submit herewith a report of the Board of Engineers for Fortifications, &c., upon the reorganization of the Engineer School of Application at Willets Point, made in compliance with instructions based upon your authority as granted in indorsement upon my letter of August 18, 1884.

In submitting this report I have to say that the first condition necessary to make the school at Willets Point efficient as a practical school of instruction for Engineer Officers is to insure its permanency.

BOARD OF VISITORS.

The Board of Engineers for Fortifications, &c., in New York, together with such other officers of the Corps of Engineers above the rank of Major as shall be stationed in New York City, should constitute a Board of Visitors, which should visit the school at least twice in each year and make a thorough and detailed inspection of everything connected with it, submitting a report thereof to the Secretary of War, through the Chief of Engineers, with such recommendations in reference to the school as may be deemed necessary.

ACADEMIC STAFF.

The Academic Staff of the School should consist of the Commanding Officer, *at least* one other field officer, and the Captains commanding the companies; the Adjutant of the Battalion of Engineers should be the secretary.

TOURS OF DUTY.

The tours of duty of the Commanding Officer and of the Field Officers detailed for the school should be as long as possible, subject to the exigencies of the service.

The regular tour of the *Captains* should not be less than three years, and only one of them should be relieved in any single year.

As the duty of instruction in some branches of the profession will probably devolve upon the Adjutant and Quartermaster, who should be First Lieutenants of high rank, the tour of each should be not less than three years, and only one of them should be relieved in any one year.

GRADUATES ASSIGNED TO THE CORPS OF ENGINEERS.

All graduates of the Military Academy who may be assigned to the Corps of Engineers, at the expiration of their graduating leave, should, as far as circumstances will permit, be ordered to the School of Application at Willets Point, and their tour of service should not be less than two and a half years.

LIBRARY.

Provision should be made from the appropriation for incidental expenses of the Engineer Depot at Willets Point for the annual purchase of a few new standard books for the library of the school.

INSTRUCTION OF ENLISTED MEN.

The enlisted men of the Battalion of Engineers should be instructed not only in their duties as soldiers of the line of the Army, but also in sapping, mining, pontoneering, the duties of a Torpedo Corps, &c.

The non-commissioned officers of the Battalion should receive theoretical as well as practical instruction.

REORGANIZATION OF THE ENGINEER SCHOOL OF APPLICATION.

The following plan of reorganization of the school, mainly a repetition of the ideas submitted in the report of the Board of Engineers, is recommended for approval.

The Establishment shall be designated *The Engineer School of Application of the Army of the United States.* It shall be divided into five departments, as follows:

Submarine Mining.—Including electricity, our own and foreign systems of defensive torpedo warfare, and modern high explosives.

Military Engineering.—Including the operations of armies in the field, seacoast defence, modern siege operations, and modern ordnance.

Military Photography.—Including all methods of map multiplication in the field and the use of the camera.

Practical Astronomy.—Including the best methods and the use of instruments employed upon the more important boundary surveys.

Civil Engineering.—Including practical surveying, river and harbor improvements, and barometric hypsometry.

OBJECT OF ESTABLISHMENT.

The object of the establishment should be to conduct researches in the branches of science applicable to the duties of the Corps of Engineers, to instruct newly assigned officers in the profession, and to train the enlisted men of the Battalion of Engineers to the highest possible degree of efficiency.

COMMAND.

The establishment, under the Chief of Engineers, should be under the military command of the officer of Engineers assigned to the command of the Post of Willets Point, N. Y.

ACADEMIC STAFF.

The Academic Staff should consist of the Commandant, of the other field officers of the school, and of the Captains commanding the Engineer companies stationed at Willets Point.

Any other officer charged with a department of instruction should be a member when his branch is under consideration. The Adjutant of the Battalion of Engineers should be secretary of the Academic Staff.

STUDENTS.

The students should consist of the subaltern officers serving with companies, of such other officers as may be authorized to study the course in whole or in part, and of the non-commissioned officers and privates of the Battalion of Engineers stationed at Willets Point.

EXAMINATIONS.

There should be two semi-annual examinations of the officers under instruction during the first and second years, and one during the last half year of their service with the Battalion. These examinations should be conducted by the Academic Staff in the presence of one or more members of the Board of Visitors. Careful records should be kept, which should be duly reported to the Chief of Engineers by the Commanding Officer of the Post.

These semi-annual examinations should take place on or about the end of January and on or about the end of April.

Their scope, subject to the approval of the Chief of Engineers, should be designated by the Commandant on the recommendation of the Academic Staff.

Officers of other arms of service attached to the school should be examined by the Academic Staff at such times as may be ordered by the Commandant, on the approval of the Chief of Engineers, and the results of such examinations should be reported, through the Chief of Engineers, to the General Commanding the Army when such officers are relieved from duty, or sooner if deemed expedient by the Academic Staff.

RESEARCHES.

The researches to be conducted at Willets Point shall be such *as may be approved by the Chief of Engineers.*

COURSE OF INSTRUCTION.

The annual course of instruction should be divided into two parts, winter and summer. The former, which will be chiefly library and laboratory work, should extend from about the first of December to about the end of April. The latter should include the rest of the year, and will be chiefly practical. So far as the season permits, theory and practice should at all times be combined.

During the summer season each member of the Academic Staff should be assigned by the Commandant to the charge of one of the departments of instruction, and so far as practicable this detail should be changed each year. In making such assignments, however, no Captain should be relieved of responsibilities which properly pertain to his military command.

During the winter season the supervision of the course should be divided among the Academic Staff.

The following should be the general programme of instruction, the details being ordered by the Commandant, upon the approval of the Chief of Engineers, upon the recommendation of the Academic Staff, which shall designate the necessary text books.

COURSE FOR OFFICERS.

The young officers should be required to assist in the various researches in military science conducted at Willets Point, with a view to familiarizing them with the methods employed in such work.

Their technical course of study should be arranged as far as practicable upon the following basis; details should be arranged by the Academic Staff:

	1st winter.	2d winter.	3d winter.
Submarine mining	14 weeks.	7 weeks.	6 weeks.
Chemistry and Military Photography	4 weeks.	4 weeks.	--------
Military Engineering	--------	7 weeks.	3 weeks.
Civil Engineering	--------	-------	11 weeks.

During the summer much time will be occupied by the regular company duties, and it is not deemed possible to arrange the course as definitely as for winter. The following schedule indicates the general disposition of time:

	1st summer.	2d summer.
Submarine mining	7 weeks.	6 weeks.
Practical Astronomy	5 weeks.	6 weeks.
Military Engineering	Sapping, mining, and pontoniering drills, infantry drills and target practice, with their companies.	
Civil Engineering	4 weeks.	7 weeks.

COURSE FOR ENLISTED MEN.

The course of instruction for the enlisted men of Engineers should be determined by the Academic Staff, and should be repeated annually, more care and time being devoted to recruits than to instructed soldiers.

In submarine mining recruits should receive three months and instructed soldiers one month of drilling, covering seven hours daily. These drills should include all the duties of the loading room, boat service, and the handling and firing of modern high explosives. Grand groups of mines should frequently be planted and raised, and the entire familiarity with the service which practice alone can give should be insisted upon.

In field fortification and sapping each company should have one months' regular practice in the moulding room, and such outside work as may be found practicable.

In pontoniering each company should have two months' regular practice, arranged to include every part of the authorized manual. In military mining on land each company should have one months' practice, including the construction and firing of mines charged with gunpowder and modern high explosives. In Infantry drill and target practice each company should be exercised enough to maintain the reputation already acquired by the Battalion in this necessary part of its duty.

In foot reconnaissance and military map making all the non-commissioned officers and many selected privates should be thoroughly instructed. In military photography and the multiplication of maps in the field all the non-commissioned officers should receive regular instruction, which for men of special aptitude should be sufficiently extended to provide each company with skilled artisans to perform this work in war.

The practice in simple reconnoitering and surveying, and in the use of the barometer already carried out should be continued not only for its own utility, but also to train the men in intelligence and in manual dexterity in the use of instruments which their field duties often demand.

As the object of this organization is to obtain a complete system of instruction, it is suggested that if the foregoing meet with approval, that such approval be given with the understanding that changes may be made from time to time by the Chief of Engineers, with the approval of the Secretary of War.

I have also the honor to recommend that there be prepared at Willets Point, under the direction of the Board of Engineers, a torpedo manual, which will present the practical method of loading and anchoring torpedoes, making all electrical connections, and firing both single mines and groups; this manual should give concise description of all boats and machinery for planting torpedoes with expedition, and the whole subject of the torpedo system should be condensed in a course of instruction similar in scope to the drill for pontoniers.

The object of this manual is, without betraying anything which in the judgment of the Chief of Engineers it is important to keep secret, that officers and even intelligent non-commissioned officers who have been

through the school of instruction, may be enabled to plant torpedoes both singly and in groups, and to manipulate them efficiently and skillfully.

In connection with the researches at Willets Point, the Commandant should from time to time inform the Board of Engineers for Fortifications, through the Chief of Engineers, of every new discovery or invention of this character, in order that the Board may be able to use such information in preparing the system of defence for various harbors throughout the United States.

I am, sir, very respectfully, your obedient servant,

JOHN NEWTON,
Chief of Engineers, Brig. and Bvt. Maj. Gen., U. S. A.

Ist Indorsement, War Department, February 28, 1885.

Approved: ROBERT T. LINCOLN,
Secretary of War.

It seems fitting that this record of the early days of the Engineer School of Application should be brought to a close at the date of its formal recognition by the War Department. I remained in command about a year longer, but as will be seen by comparing the approved document with my letter above there was no radical change in the establishment. There were no recitations and no published marks, or standings. The school had attained its growth naturally, seeking to assist and not to drive officers in preparing for their life work. Such had been the basis of General Humphreys' original plan and instructions.

It only remains to name the Captains and Battalion staff officers who, as the instructors at Willets Point, had one and all most cordially and efficiently assisted in the work. They were in order of assignment: Captains Harwood, Howell, Holgate, Burnham, Mansfield, · Ernst, Mackenzie, King, Raymond, Twining, Livermore, Cuyler, Mercur, Miller, Handbury, Gregory, Mallery, Ruffner, Price, Palfrey, Mahan, Bailey and Knight. Battalion Adjutants; Lieutants A. N. Lee, Maguire, Hinman, Heuer, Mercur, Bass, Leach, Greene, Quinn, Mallery, Fisk, Griffin, Willard, Bixby, Millis, Hodges, Warren, Crosby and Roessler. Battalion Quartermasters; Lieutenants Heap, Chase, Powell, Davis, Payson, Greene, Taber, Quinn, Griffin and Lusk. My association with these officers, and with the nearly fifty young students who have since so worthily maintained the reputation of the Corps, will always form one of my most pleasant memories.

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